Which Way Should I Point?

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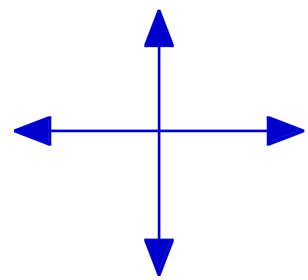
Objective

Cassini is carrying 12 science instruments to Saturn. All 12 of these instruments are "body fixed" which means that in order to point one instrument at Saturn, the entire spacecraft must be turned. This activity is designed to demonstrate how difficult the mission planner’s job can become when all 12 of Cassini’s instruments want to collect data at the same time.



Discussion

The Voyager and Galileo spacecraft had some instruments mounted to a scan platform. This scan platform is a mounting frame that can move independently from the rest of the spacecraft, just like a robotic arm. Cassini, in contrast, does not have a scan platform. All of Cassini’s science instruments are attached directly to the main body of the spacecraft. As a result, in order to move an instrument to take an image of Saturn (or any other target), the entire spacecraft must move. This means that while the camera is taking a picture of Saturn, all of the other instruments must look in their pre-defined directions. This makes coordinating observations and data collection using the 12 instruments very difficult.

Materials Needed:

- A desk chair that swivels
- A board that is wide enough and thick enough to support three people
- A hat preferably a cowboy, outback, or other brimmed hat
- One small toy telescope
- One pair of binoculars
- A broom handle (available at hardware stores or large wholesale kitchen supply stores)
- Three student volunteers
- An image of Saturn - this can be a photograph, a store bought cut-out, or a drawing

Procedure

- Mount the image of Saturn somewhere in the classroom.
- Place the board on the swivel chair.
- Place the first student volunteer in the center of the board. Place the hat upside-down on top of his/her head. The hat represents Cassini’s high gain antenna (the main communication antenna for the spacecraft).
- Give the student the small toy telescope and instruct him/her that the telescope can only move up and down. The telescope will represent the Magnetospheric Imaging Instrument (MIMI).

- With someone holding one end of the board so that it does not tip over, place the second student volunteer on the other end of the board with his/her back to the person in the center. Give the second student the binoculars. These binoculars represent the Imaging Science Subsystem (ISS). One lens of the binoculars is the wide angle camera and the other lens is the narrow angle camera. Instruct the student that he/she can only look straight ahead.
- Place the third student volunteer on the other end of the board with his/her back toward the person in the center. Give the third student the broom handle and instruct him/her to hold it out in front. The broom handle represents the Magnetometer (MAG).

Taking Data With The "Spacecraft"
Now that all three of the students are in position, it's time to take some data of Saturn. First, have someone hold up the Saturn image. Let's try to collect some data.

Magnetometer (MAG) is collecting data on Saturn's magnetic field. Therefore, as long as the instrument is turned on, it does not need to point in any particular direction (for the purpose of this demonstration).

Magnetospheric Imaging Instrument (MIMI) and Imaging Science Subsystem (ISS) are a whole different story. Since both ISS and MIMI need to actually look (point) at Saturn to collect data, it's obvious that they cannot collect data at the same time. In real mission planning, there is a sequence of events that is pre-defined where one of these instruments will collect data and then the other will have a chance. The excitement comes when both science teams want to collect data at the same time. The mission planning team then needs to negotiate a bargain between the two instruments.

Remember that this demonstration only uses three of Cassini's twelve instruments!

Extension
Enhance the difference between a body-mounted spacecraft like Cassini and a spacecraft with a scan platform like Galileo. The main demonstration illustrates the difficulties presented to the Cassini science and engineering teams when they attempt to collect data using multiple instruments. Now let's examine how Galileo works.

The Galileo spacecraft has a similar design to Cassini. Galileo has a main antenna at the top of the spacecraft, a central core of electronics, and a main engine at the bottom of the spacecraft. Science instruments are mounted on the outside of the central core. The main exception between Galileo and Cassini is the movable scan platform that allows Galileo's imaging instruments (cameras) to be positioned to take data almost independent of the spacecraft's position.

On the Galileo spacecraft, your student camera (the student with the binoculars) is now free to move his binoculars in order to capture a target. Repeat the procedure for Cassini, only as you rotate the chair, allow the "camera" to stay pointed at Saturn until the chair is rotated so much that the "camera" is on the other side of the spacecraft from Saturn.

Standards
A visit to the URL http://www.mcrel.org yielded the following standards and included benchmarks that may be applicable to this activity.

Technology Standard 4. *Understands the nature of technological design.*

Level I Primary (K-2) : Knows that people are always inventing new ways to solve problems and get work done (e.g., computer is a machine that helps people work and play).
Level II Upper Elementary (3-5): Knows constraints that must be considered when designing a solution to a problem (e.g., cost, materials, time, space, safety, scientific laws, engineering principles, construction techniques, appearance, environmental impact, what will happen if the solution fails).
Level I Primary (K-2): Implements proposed solutions using appropriate tools, techniques, and quantitative measurements.
Level III Middle School (6-8): Evaluates the ability of a technological design to meet criteria established in the original purpose (e.g., considers factors that might affect acceptability and suitability for intended users or beneficiaries; measures of quality with respect to these factors), suggests improvements, and tries proposed modifications.
Level IV High School (9-12): Evaluates a designed solution and its consequences based on the needs or criteria the solution was designed to meet.

Technology Standard 5. *Understands the nature and operation of systems.*
Level I Primary School (K-2): Understands how some elements or components of simple systems work together (e.g., parts of a bicycle).
Level II Upper Elementary (3-5): Knows that when things are made up of many parts, the parts usually affect one another.
Level II Upper Elementary (3-5): Identifies the relationships between elements (i.e., components, such as people or parts) in systems.
Level III Middle School (6-8): Knows that systems are usually linked to other systems, both internally and externally, and can contain subsystems as well as operate as subsystems.

NOTE: This activity is currently posted to the Cassini web site as a field-test version. Educators who use this activity for classroom demonstration purposes are encouraged to submit comments to the Cassini Education Outreach Coordinator. We are dedicated to providing high-quality activities for classroom use and welcome your suggestions.

Which Way Should I Point? Student Sheet

The instructor will engage you, the student, in this demonstration. Some additional questions to answer include:

1. With the fixed body spacecraft, can both instruments take data of Saturn at the same time?

2. If the answer to #1 is "no," how can the 2 instruments both collect data of Saturn?

3. Is it easier for the two instruments on the Galileo spacecraft (with the moveable scan platform) to collect data at the same time?

4. Which spacecraft design, the fixed body spacecraft or the one with the scan platform, do you think costs more to build? Why?